Amendments to the Specification:

Please replace the Specification of the present application, including the Abstract, with the following Substitute Specification. A marked-up version of the Substitute Specification and Abstract is attached hereto.

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SPECIFICATION

TITLE OF THE INVENTION

METHOD FOR PRODUCING ELECTRIC CONDUCTIVE STRUCTURES FOR USE IN HIGH FREQUENCY TECHNOLOGY

BACKGROUND OF THE INVENTION

[0001] Current circuit board technology requires very large structures for resonators, bandpass filters, band-stop filters and spiral inductors. For applications with thinner insulation layers, typically of an order of magnitude of 50 μm, the current relatively high conductor track tolerances for series products often do not allow the use of microstrip conductors. In any event, the possible uses of microstrip conductors are greatly restricted by the relatively high conductor track tolerances. They are not, for example, currently suitable for high frequency technology applications. For applications with ceramics, long throughput times are needed compared to circuit boards serving as conductive structures. In addition, the yield in the use of ceramics is significantly less desirable when compared to printed circuit boards. Ceramics also is not suitable for use as an optical carrier.

[0002] To avoid the large structures for resonators, bandpass filters, band-block filters and spiral inductors, for reasons of space, components previously have been placed on the surface of the circuit board. These components then increase the cost of the board. Added to this were the costs of actually placing the components on the circuit board. A further disadvantage was that areas had to be prepared on the surface of the circuit board to accept the components.

[0003] Microstrip conductors, however were already used on what are known as FR 4 printed circuit boards with sufficiently large available areas in the HF part. However this was restricted particularly to areas of the surface which have a comparatively large layer spacing of, for example, > 100 μm to the HF structures. Tolerances in the conductor tracks could be accepted for these layer spacings.

[0004] A method for producing electric conductive structures on a conductive structure carrier is known from document EP-A-0 530 564 A564 with tin or a tin-lead alloy being used as a resist. A resist layer is applied to a metal layer

and structured with the aid of a laser. The areas of the metal layer revealed are then removed by etching.

[0005] In addition, for example, in particular the resist ma-N 2403 in the resist series ma-N 2400 from micro resist technology GmbH is known from product information, Rev. : 2/01 for example, which, as a resist, in comparison to chemical tin, has properties as a resist with regard to lasering in the laser structuring method, etching in the etch method and the minimum thickness with which it can be applied on a conductor carrier which at least correspond to those of chemical tin or an amorphous resist.

[0006] The present invention seeks to provide a method for producing electric conductive structures for use in high frequency technology on a conductive structure carrier with layer spacings of significantly less than 100 μm using microstrip conductors.

SUMMARY OF THE INVENTION

[0007] Accordingly, a combination of laser structuring methods and etching methods is used in connection with a resist with high adhesion which, at least with regard to the lasering in the laser structuring methods, the etching in the etching methods and the minimum thickness with which it can be applied to the conductive structure carrier, has properties which at least correspond to those of chemical tin or an amorphous resist.

[0008] Chemical tin can be applied at a strength of around 1 μm. An amorphous resist can be applied at a strength of far less than 20 μm. The thinner a resist can be applied, the better it is for the current method. Previous resists had a layer thickness of far greater than 20 μm. The far thinner resists allow laser treatment to be performed far more precisely. With an optimized fabrication process, structures extending down into the 20 or 10 μm range and lower are thus possible. These fine structures enable electric conductive structures that can be used with high-frequency technology to be embodied, replacing the conventional components with their corresponding disadvantages, which otherwise would be needed. In particular, the conductor structures can be embodied so as to form capacitors, coils and resistors with the desired values and occupying the smallest

space for use with high-frequency technology. In this case, the laser structuring method allows structuring which is relatively simple compared to photographic methods but can still be undertaken at high speed. The combination of a laser structuring method with an etching method has the further advantage that full surface areas can be removed at the same time as the removal of other areas. This saves time but is also frequently needed so that the electric conductive structures used for high frequency technology are not adversely affected by the electrical voltage fields which might be present because of the full-surface areas.

[0009] Overall, this method allows structured conductor tracks with small tolerances to be implemented on the inner layers or on the outer layers of a circuit board as microstrip conductors with almost any given functions over the entire fabricated wafer. The conductor track width can be restricted to almost any degree. Currently, tolerances of < +/- 5 μm are already possible. Previously typical tolerances were in the size range of +/-25 μm.

[0010] Additional features and advantages of the present invention are described in, and will be apparent from, the following Detailed Description of the Invention and the Figures.

BRIEF DESCRIPTION OF THE FIGURES

[0011] Figure 1 shows a basic procedural sequence of the method in accordance with the present invention.

[0012] Figure 2 shows a part of a larger circuit board structure fabricated using the method in accordance with Figure 1, shown in cross-section with a conductor structure usable with high-frequency technology and a structure not usable with high-frequency technology.

[0013] Figure 3 shows a comparison in size between a conductor structure in accordance with the present invention and in accordance with a corresponding conventional technology.

[0014] Figures 4 to 7 shows the steps involved in producing a coil in accordance with the present invention.

[0015] Figures 8 to 10 shows a side view of three completed applications in a circuit board which have been implemented in accordance with the present invention.

[0016] Figure 11 and 12 shows further applications in accordance with the present invention.

[0017] Figures 13 to 16 shows application examples in accordance with the present invention in relation to a capacitor, a coil, a resistor and a moisture sensor.

DETAILED DESCRIPTION OF THE INVENTION

[0018] The laser-structured Partial High Density Interconnection (PHDI) shown in Figure 1 shows a conductor structure carrier 1 (substrate, shows as an FR4 circuit board), of which the surface is initially pre-treated in an appropriate manner so as to enable a thin layer 2 of chemical copper to be applied. In a subsequent electrolytic coating, a further copper coating 3 is then applied, with a total coating thickness of up to 20 μm in the current exemplary embodiment.

[0019] Thereafter, a thin resist layer 4, here consisting of chemical tin, with a layer thickness of around 1 μm, is applied.

[0020] The coating phase is followed by a structuring phase. The structuring is performed with a laser 5, as shown in Figure 1. In the structuring phase, the chemical tin layer 4 is milled away with the laser 5 at those points at which the copper coating 3 below the chemical tin layer 4 is to be subsequently removed.

[0021] After the structuring phase, as already indicated, the revealed copper layer 3 is etched away. Finally, the chemical tin layer still present is stripped away.

[0022] In Figure 2, the area at the top left shows an inventive conductor structure 6 whereas the area in the center is a conventional conductor structure 7.

[0023] The inventive conductor structure 6, which is a new HF structure, features coating gaps 8 of, for example, 30 μm. By contrast, the conventional conductor structure 7 features coating gaps 9 of, for example, 180 μm.

[0024] Also shown in Figure 2 in connection with the new HF structures is an individual micro pass-through contacting 10 and a number of microstrip conductors 11 of high quality.

[0025] Figure 3 shows a visual comparison of the size of the surface areas when a specified line structure is implemented in accordance with the present invention, that is in new technology 12, and in accordance with conventiconal (.e., old) technology 13.

[0026] Figures 4 to 7 illustrate the step-by-step implementation of a coil formed of microstrip conductors in accordance with the present invention. Figure 4 shows a copper surface with an edge length of 1 mm. The copper surface is structured with a laser in the individual production steps. In Figure 5, a coil shaped like a snail can be seen. In Figure 6, the disruptive edge surfaces have been removed. In Figure 7, the coil is completed.

[0027] Figures 8 to 10 again show a side view of completed applications, based here on coils in each case. The shape and size of the Figures can be chosen at random. In the exemplary embodiment shown, the most compact form was selected in each case.

[0028] Figure 11 shows a possible application within the circuit board below a component. In the form shown, no component placement surface of the circuit board is needed. The coil also could be accommodated at any other points in the layout.

[0029] In detail, a component 14 can be seen which is connected in a substrate L1 with a pad 15. Below the substrate L15 or the pad 8, in a substrate L2 in new technology a coiled conductor structure is implemented, as is also shown in Figure 8, for example. Below the substrate 2 and below the coiled conductor structure, a substrate L3 corresponding the substrate L1 is arranged.

[0030] There is also an enlarged view of the section integrated into Figure 11 which shows an enlargement of the surface and the depth around pad 15. Here, the enlarged section also shows an individual micro through-contacting 16, with which in the present exemplary embodiment through-contacting between substrate L1 and substrate L2 is established.

[0031] Figure 12 shows an application as capacitors below a pad. The use of suitable insulating coatings and low coating thicknesses below them (e.g., up to 25 μm), allow capacitors typically ranging up to 20 pF to be implemented in the

smallest space. These capacitors have the additional advantage of barely having any inductive effect.

[0032] In detail, a component 17 can be seen which is connected in a substrate L1 with a pad 18. Below the substrate L1 or below the pad 18 in a substrate L2 a conductor piece 19 is implemented in new technology, below this again in a substrate L3 a further pad 20 is arranged. In this case, a first insulation layer 21 or a second insulation layer 22 are arranged between the substrate L1 and the conductor piece 19 on one side and between the conductor piece 19 and the substrate L3 on the other side. To summarize, a multilayer capacitor between the pads 18, 20 is implemented with this arrangement.

[0033] A further enlarged sectional view is also integrated into Figure 12, as in Figure 11, showing an enlarged area of the depth and the surface around the pad 18.

[0034] Figure 13 shows a application relating to an HF capacitor. Figure 14 shows an application relating to an HF coil. Figure 15 shows an application relating to an HF resistor and Figure 16 shows an application relating to a moisture sensor.

[0035] The components in this case are positioned in Figures 13, 14, 15 within a component area BE-F covered by a component next to a component pad surface BE-P which also can be seen as a component solder surface piece BE-A for an electrical connection with these components.

[0036] In Figure 16, the component involved is shown on its own.

[0037] For the embodiment of the HF capacitor shown in Figure 13 with an HF structure 23 in PHDI technology, a capacitor surface area 24 of around 1 mm^2 is needed for the capacitor to have a capacitance of 1 pF. In this case, high-quality conductor tracks 25 for the connection of the capacitor have a width of about 20 µm, for example.

[0038] For the embodiment of the HF coil with an HF structure 26 in PHDI technology shown in Figure 14, a coil surface for an approximately 15 mm long stripline is needed which is achieved with high quality with a conductor track 27.

[0039] A micro through-contacting 28 with a diameter of 0.08 mm is implemented for a midpoint connection of the coil.

[0040] For the embodiment of the HF resistor shown in Figure 15, a first copper layer for a first connection surface 29 and a second copper layer for a second connection surface 30 are implemented, between which a prespecified foil type is interleaved.

[0041] The connection surfaces 29, 30 combined as surfaces 32 are high-quality surfaces. Resistance values of the HF resistor are determined using the interleaved foil type and the connection surfaces. The calibration is undertaken in PHDI technology.

[0042] The exemplary embodiment in accordance with Figure 15 finally shows a conductor track 33 for the first connection and a conductor track 34 for the second connection of the HF resistor.

[0043] The moisture sensor depicted in Figure 16 is shown at two points in time. In the upper part of Figure 16, the moisture sensor is shown before the laser process whereas in the lower part of Figure 16 it is shown after the laser process.

[0044] Before the laser process there only exists one high-quality surface 35 into which conductor tracks 36 with a high-quality width are incorporated with the laser process. The width in the exemplary embodiment shown is at least 25 µm.

[0045] For the moisture sensor in Figure 16, conductor tracks 37 are used for its connection which, in the exemplary embodiment shown, have a width of 0.1 mm.

[0046] Although the present invention has been described with reference to specific embodiments, those of skill in the art will recognize that changes may be made thereto without departing from the spirit and scope of the present invention as set forth in the hereafter appended claims.